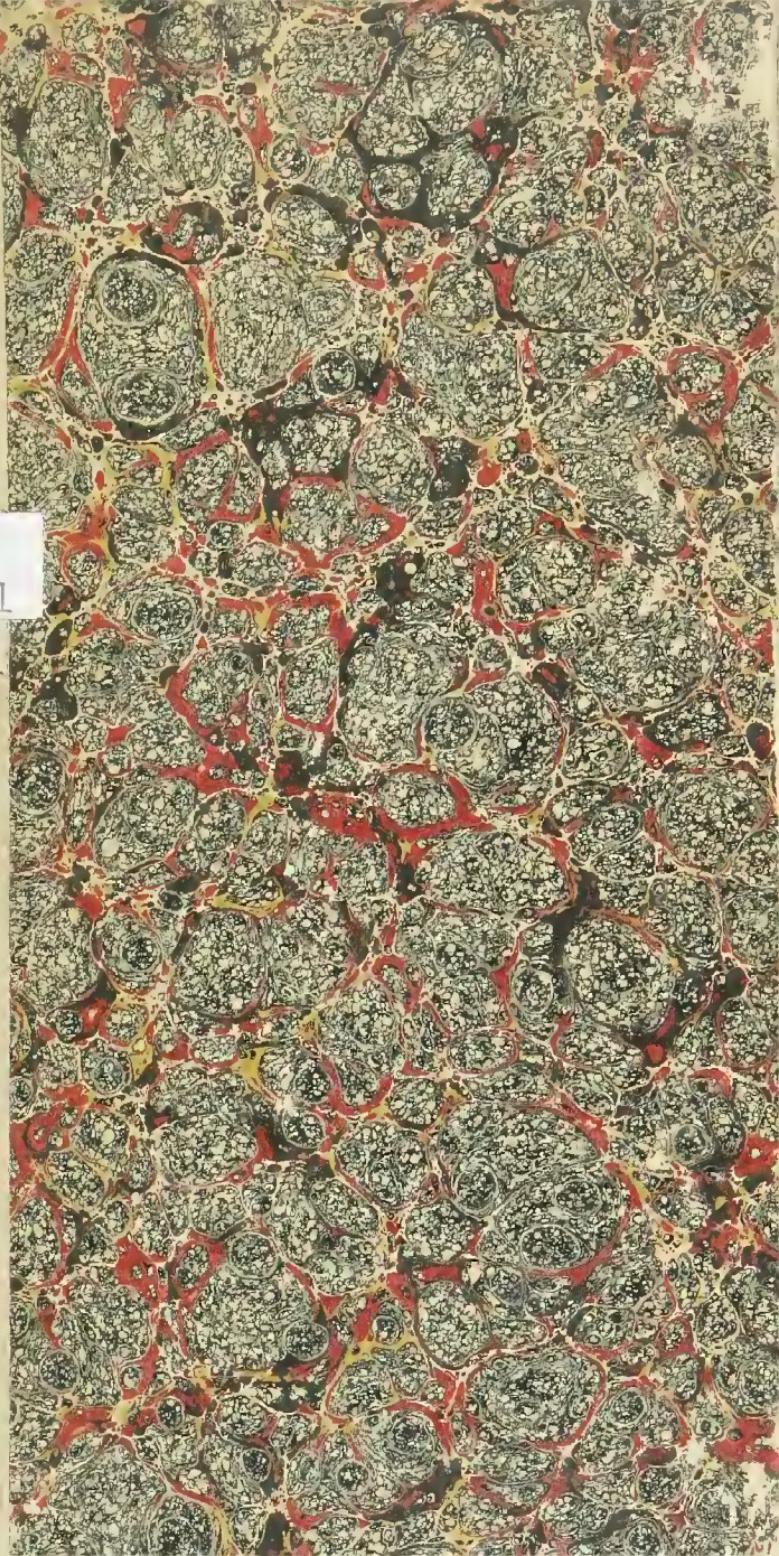


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of Water etc.

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OF

WATER, MILK, BREAD, &c.

BY

GEORGE BIDIE

SURGEON LIEUTENANT, INDIAN MEDICAL SERVICE (MADRAS)

MEDICAL OFFICER, 6TH INFANTRY, HYDERABAD

CONTINGENT



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LABORATORY ANALYSIS

OF

WATER, MILK, BREAD, &c.

BY

GEORGE BIDIE

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LONDON

H E N R Y K I M P T O N

82 HIGH HOLBORN, W.C.



P R E F A C E

THE following notes on the laboratory analysis of water, milk, &c., I have compiled with the hope that they may be of some use to my brother officers in the Army and Indian Medical Services, as well as to others.

I here take the opportunity of acknowledging my indebtedness, for much valuable information, to the late Dr. Parkes' work on "Practical Hygiene," edited by Professor Lane Notter, to whom I am personally indebted for his kindness in permitting me to make use of the "Standard Solutions" contained therein.

G. B.

BERRY VIEW, PAIGNTON,
March 1895.

ABBREVIATIONS

| | | | |
|---------------|---------------------|-----------------|----------------------|
| ppt. | = precipitate. | NO_3 | = nitric acid. |
| c.c. | = cubic centimetre. | \bar{A} | = acetic acid. |
| lb. | = pound. | \bar{L} | = lactic acid. |
| gr. | = grain. | \bar{C} | = citric acid. |
| gm. | = gramme. | NH_3 | = ammonia. |
| mgm. | = milligramme. | CaO | = lime. |
| oz. | = ounce. | CaCO_3 | = calcium carbonate. |
| Fh. | = Fahrenheit. | CO_2 | = carbon dioxide. |
| c. | = centigrade. | \therefore | = therefore. |
| sol. | = solution. | $-$ | = minus. |
| NO_2 | = nitrous acid. | $+$ | = plus. |

LABORATORY ANALYSIS

WATER.

Physical Examination.

Colour, generally grey or yellow.

Turbidity, „ none.

Sediment, „ some.

Lustre, „ none.

Taste, „ earthy } or { pleasant,
Smell, „ earthy } or { unpleasant,
or none.

Qualitative Examination.

Reaction.—As a rule it is neutral ; it may be feebly acid.

| Element sought for. | Reagents used. | Reaction. | Result. |
|---------------------|--|--|--|
| LIME . . . | Ammonium oxalate. | White ppt. | Large amount or small, as case may be. |
| CHLORINE . . | Silver nitrate and dilute nitric acid. | White ppt. | Do. |
| SULPHURIC ACID . . | Barium chloride and dilute hydrochloric acid. (Take $\frac{1}{3}$ quantity) | White ppt. | Do. |
| PHOSPHORIC ACID . . | ammonium molybdate and dilute nitric acid. Boil. | Yellow colour, and (on standing for a time) a ppt. | Do. |

Qualitative Examination—continued.

| Element sought for. | Reagents used. | Reaction. | Result. |
|---------------------|--|--|--|
| AMMONIA . | Nessler's reagent. | Yellow colour, or yellow- brown ppt. | Large amount or small, as case may be. |
| NITROUS ACID . | Starch and potassium iodide solution and dilute sulphuric acid. (Take $\frac{1}{2}$ quantity) | Blue colour. | Do. |
| NITRIC ACID | brucin solution and strong sulphuric acid. <i>Pour gently.</i> | Play of colours, forming pink and yellow zone. | Do. |
| ORGANIC MATTER . | (Take 100 c.c.) chloride of gold. <i>Boil 20 minutes.</i> | Pink or dark rings round the dish. | Do. |

Metals.

| | | | |
|----------|--|--|-----|
| IRON : . | Ammonium sulphide. | Dark colour, cleared up by hydrochloric acid, if it be IRON. | ... |
| LEAD : . | (To original solution) potassium iodide. | Yellow ppt. | ... |
| COPPER . | (To original solution) cyanide of iron. | Chocolate ppt. | ... |
| ZINC . | (To original solution) sulphureted hydrogen. | White colour. | ... |

Quantitative Analysis.

CHLORINE.

Take 100 c.c. of the water in a glass vessel standing on white paper, and add 1 c.c. potassium monochromate.

Now add standard solution of silver nitrate till a permanent red tint appears, then stop. Read off the number of c.c.'s. of standard silver nitrate solution used. Say 4 c.c.'s have been used, and each c.c. of silver solution equals 1 mgm. of chlorine,

$$\begin{aligned}
 4 \times 1 &= \text{parts per } 100,000, \\
 1 \text{ lb. avoirdupois} &= 7000 \text{ grains}, \\
 10 \text{ lbs.} &= 1 \text{ gallon}, \\
 1 \text{ gallon} &= 70,000 \text{ grains}; \\
 \therefore 100,000 : 70,000 &:: 4 : x \\
 1 : .7 &:: 4 : x \\
 4 \times .7 &= 2.8 \text{ grains per gallon of chlorine.}
 \end{aligned}$$

HARDNESS.

Total.—Take 50 c.c. of the water in a small 6 oz. bottle. Add the soap solution, and shake after the addition of every 2 measures, stopping when a thin beady lather (permanent for 10 minutes) appears. Say 20 measures have been used (1 measure equals $\frac{1}{10}$ c.c.), and purest water requires 2 measures; deduct these 2 measures from the 20 measures used—therefore 18 net measures have been used. Each measure of soap solution equals .25 mgm. calcium carbonate,

$$\begin{aligned}
 \therefore 18 \times .25 &= 4.5 \text{ mgms. calcium carbonate in } 50 \text{ cc.} \\
 &\quad \text{of the water,} \\
 &= \text{parts per } 50,000; \\
 \therefore 4.5 \times 2 &= 9 = \text{parts per } 100,000.
 \end{aligned}$$

Fixed.—Boil some of the water for 20 minutes, and restore it to its original bulk with distilled water, after cooling. For estimation of the amount of fixed hardness, take 50 c.c. of this boiled water, and proceed as before.

Removable is the difference between the amounts of fixed and total hardness.

NITROUS ACID, OR NITRITES.**Griess' Method.**

Take 100 c.c. of the water in a Nessler glass, and drop in 1 c.c. of the sulphuric acid solution (1 in 3), also 1 c.c. of meta-phenylenediamine, when we get a yellow colour.

In another Nessler glass put in as much of the standard potassium nitrite solution as necessary, filling up with distilled water to 100 c.c., and add 1 c.c. each of the solutions of sulphuric acid and meta-phenylenediamine.

In the case of the first glass, if the yellow colour do not appear immediately, less than 7 c.c. of the standard solution will in all probability be required to be put into the second glass to give a corresponding colour to that in the first glass.

If, however, we obtain the yellow or orange colour at once in our first glass, we shall be near the necessary amount of potassium nitrite solution to be used if we run in from 6 c.c. to 10 c.c. of the standard potassium solution into our second glass, carefully comparing the tints of the two glasses, and stopping whenever they correspond exactly.

If no yellow colour appears at once on addition of the sulphuric acid and meta-phenylenediamine into the first glass containing 100 c.c. of the water to be examined, it is as well to begin with only 3 c.c. to 5 c.c. of the standard potassium solution in the second glass.

However, 8 c.c. of the potassium nitrite solution is the amount usually required.

Say 8 c.c. were used (in 100 c.c.),

and each c.c. = .01 mgm. of NO_2 ;

\therefore 8 c.c. = .08 mgm. of NO_2

in 100 c.c. of the water.

If 1 c.c. of the water had been used and .08 mgm. of NO_2 were found, that would be .08 per 1000; therefore it is .08 parts per 100,000.

Tidy's Process.

Carried on at a temperature of 80° Fh. (or $26^{\circ}.7$ C.).

Take two flasks—one with 250 c.c. distilled water, the other with 250 c.c. of the water to be examined. Into each put 3 c.c. of strong sulphuric acid. Heat both flasks to the above temperature, and add, to each, 10 c.c. of a standard potassium permanganate solution. Let them stand for quarter of an hour, and then add to each 3 or 4 drops of potassium iodide solution, when the colour will change from a pink to a sherry colour. Now run in hyposulphite of soda solution into both, shaking flask as you proceed until the yellow colour almost disappears. Now add 1 c.c. of the starch solution to change the colour to blue. Again add the hyposulphite of soda solution carefully until the blue colour disappears, then read off the number of cubic centimetres (c.c.) of hyposulphite solution used.

Let A = flask containing distilled water.

B = „ „ „ water under examination.

Say 30 c.c. hyposulphite solution were used in the case of flask A, and 12 c.c. in the case of flask B,

$$\therefore A - B = 18 \text{ c.c.};$$

and if

Permanganate
of Potash.

$$30 : 18 :: 10 : x,$$

$x = 6$ c.c. Permanganate of potash solution used.

250 c.c. of water were taken for examination, therefore

250 c.c. of the water required 6 c.c. of the permanganate solution; and each c.c. permanganate solution equals .1 mgm. of oxygen,

$$\begin{aligned}\therefore 6 \times .1 &= .6 \text{ mgm. of oxygen in } 250 \text{ c.c. water,} \\ &= .6 \text{ parts in } 250,000, \\ 250,000 : 100,000 &:: .6 : x. \\ x &= .24 \text{ parts per } 100,000,\end{aligned}$$

representing the amount of oxidisable matter present.

De Chaumont's Process.

Total Amount of Oxidisable Matter.—Take 250 c.c. of the water in an open dish. To this add 3 c.c. of sulphuric acid, and then drop in enough potassium permanganate solution to produce a slight pink tint. Now apply heat up to 140° Fh., still continuing to add permanganate solution. Stop adding permanganate solution when we get a permanent pink tint (lasting 10 minutes). Say 6 c.c. of potassium permanganate were used, and each c.c. equals .1 mgm. of oxygen.

$$\begin{aligned}\therefore 6 \times .1 &= .6 \text{ mgm. in } 250 \text{ c.c. water,} \\ &= \text{parts in } 250,000; \\ 250,000 : 100,000 &:: .6 : x. \\ x &= .24 \text{ parts per } 100,000.\end{aligned}$$

Fixed Amount.—Take 250 c.c. of the water in a similar dish, add 3 c.c. of sulphuric acid, and boil for 20 minutes (boiling more than half the bulk away). Now cool down to 140° Fh., and add potassium permanganate solution till the pink tint lasts 10 minutes.

Say 4 c.c. of permanganate solution have been used, and each c.c. equals .1 mgm. of oxygen,

$$4 \times .1 = .4 \text{ parts per } 250,000;$$

$$\therefore 250,000 : 100,000 :: .4 : x.$$

$$x = .16 \text{ parts per } 100,000.$$

Total = .24

Fixed = .16

.08 amount of oxygen for NO_2 .

Atomic weight of oxygen = 16,

$$\text{, , } \text{NO}_2 = 46,$$

$$\therefore 16 : .08 :: 46 : x.$$

$$x = .23 \text{ parts per } 100,000 \text{ of } \text{NO}_2.$$

LEAD.

Take 100 c.c. of the water in a Nessler glass, and add .5 c.c. of ammonium sulphide solution, which gives a dark coloration.

In another Nessler glass put 1 c.c. or 2 c.c. of a standard lead acetate solution (of which 1 c.c. equals .1 mgm. of lead).

Say 2 c.c. of lead acetate solution were used,

$$2 \times .1 = .2 \text{ parts per } 100,000;$$

$$\therefore .2 \times .7 = .14 \text{ grains per gallon.}$$

$$\frac{14}{100} = \frac{7}{50}, \text{ or about } \frac{1}{7} \text{ grain per gallon.}$$

(Limit of lead in water for safety is about $\frac{1}{20}$ grain per gallon of water.)

AMMONIA.

Free.—Place 250 c.c. of the water in a retort and boil. Distil over 130 c.c., of which take 100 c.c. and to it add $1\frac{1}{2}$ c.c. of Nessler's reagent, when we obtain a yellow colour.

Take another glass and put in it about 5 c.c. to 6 c.c.

of standard ammonium chloride solution, and fill it up to 100 c.c. with distilled water, and finally add $1\frac{1}{2}$ c.c. of Nessler's reagent.

Suppose the colours in the two glasses correspond, and let us suppose that 5 c.c. of the standard ammonium chloride solution was used. But 30 c.c. of the distillate were left in the retort;

$$\therefore 100 : 130 :: 5 : x.$$

$$x = 6.5 \text{ c.c.},$$

and the whole amount of the ammonia in the 250 c.c. of the water originally put into the retort must have been the same as that contained in 6.5 c.c. of the standard solution—also each c.c. of the standard solution equals .01 mgm. of ammonia;

$$\therefore 6.5 \times .01 = .065 \text{ mgm. of } \text{NH}_3 \\ = \text{parts per } 250,000,$$

$$250,000 : 100,000 :: .065 : x.$$

$$x = .026 \text{ parts per } 100,000 \text{ of "free ammonia."}$$

Albuminoid.—To the residue left in the retort (in the above analysis for "free ammonia") add 25 c.c. of a strong alkaline permanganate solution and 50 c.c. of distilled water.

Distil from it about 120 c.c., of which take 100 c.c. and add 1.5 c.c. of Nessler's reagent, and then proceed as for "free ammonia."

NITRIC ACID.

Into a retort put 100 c.c. of the water, and also 100 c.c. of a solution of caustic soda, and as much of aluminium foil as will not all dissolve. Of this distil over 150 c.c. (By this proceeding all the NO_2 and NO_3 present have been converted into NH_3 .)

Take 10 c.c. of the distillate, and make it up to 100 c.c.

with distilled water. Then add $1\frac{1}{2}$ c.c. of Nessler's reagent, when a coloration is produced.

Take another glass, and put into it as many cubic centimetres of the standard ammonium chloride solution as will give a colour corresponding to that in the first glass, with the same amount of Nessler's reagent ($1\frac{1}{2}$ c.c.).

Say 7 c.c. of the standard ammonium chloride solution were used to give a corresponding colour,

$$\therefore 10 : 150 :: 7 : x.$$

$x = 105$ c.c. ammonium chloride solution would have been required for the whole distillate, and 1 c.c. ammonium chloride solution equals .01 mgm. of ammonia;

$$\begin{aligned}\therefore 105 \times .01 &= 1.05 \text{ mgm. of } \text{NH}_3 \text{ in } 100 \text{ c.c. water} \\ &= \text{parts per } 100,000 \\ &= \text{total amount of ammonia present.}\end{aligned}$$

Now, suppose we have already ascertained that the water under examination contains of *free ammonia* .005 mgms. per litre, we must deduct this, and

$$\begin{aligned}1 \text{ gramme} &= 10 \text{ decigrammes,} \\ 1 \text{ , ,} &= 100 \text{ centigrammes,} \\ 1 \text{ , ,} &= 1000 \text{ milligrammes,} \\ \text{and } 10 \text{ milligrammes} &= 1 \text{ centigramme;} \\ \therefore .005 \text{ milligramme} &= .0005 \text{ centigramme;} \\ \text{and } \therefore 1.05 - .0005 &= 1.0495 \\ &= \text{amount of ammonia present due} \\ &\quad \text{to } \text{NO}_2 \text{ and } \text{NO}_3.\end{aligned}$$

Again, we will suppose that we have already ascertained that the amount of *nitrous acid* present in the water is .023 centigramme per litre, and the

$$\begin{aligned}\text{atomic weight of } \text{NO}_2 &= 46, \\ \text{, , , } \text{NH}_3 &= 17; \\ \therefore 46 : .023 &:: 17 : x. \\ x = .0085 &= \text{amount of ammonia present due to } \text{NO}_2.\end{aligned}$$

$\therefore 1.0495 - .0085 = 1.0410$.
 = amount of ammonia present
 due to NO_3 ,
 and the atomic weight of $\text{NH}_3 = 17$,
 " " $\text{NO}_3 = 62$;
 $\therefore 17 : 1.0410 :: 62 : x$.
 $x = 3.7965$
 = parts per 100,000 of *nitric acid*.

BEER.

It should be transparent, it should not taste too acid, and the bitter taste should not persist. The specific gravity should be taken not only before but after the alcohol has been driven off. The acidity of beer consists of—volatile and non-volatile.

(1.) *Amount of Alcohol present.*—Suppose the 1st specific gravity = 1007. Now take 200 c.c. of the beer, evaporate it down to $\frac{1}{3}$ of its bulk, cool it, and make it up to its original bulk (200 c.c.) with distilled water. Next take the 2nd specific gravity, and, say, it is 1013. Subtract the 1st from the 2nd specific gravity, thus:—

$$1013 - 1007 = 6 \text{ degrees of difference}$$

= amount of *alcohol* present.

$$\text{Now } 1000 - 6 = 994.$$

An examination of the Table (page 23) for the percentage of alcohol shows us that this number 994 represents about 3 *per cent. of alcohol*.

(2.) *Amount of Extract present.*—For the amount of extract per cent. present, we divide the 2nd specific gravity minus 1000 by 4 (working by means of a factor), thus:—

$$\frac{1013 - 1000}{4} = \frac{13}{4} = 3\frac{1}{4}$$

= percentage of *extract* present.

(3.) Acidities: (α) Total.—Take 10 c.c. of the beer to be examined, and drop in from a burette the alkaline solution of a known strength till it is neutral. Suppose it required 3.5 c.c. of the alkaline solution, and each c.c. of the alkaline solution equals 6 mgms. of acetic acid (\bar{A});

∴ in 10 c.c. of the beer there are 21 mgms. of acetic acid (\bar{A})

and 1 gallon = 70,000 grains;

$$\therefore 21 \times 7 = 147 = \text{grains per gallon},$$

and 8 pints = 1 gallon;

$$\therefore \frac{147}{8} = 18.375 \text{ grains per pint of acetic acid } (\bar{A}).$$

(β) Fixed.—Take 10 c.c. of dealcoholised beer, and neutralise as before.

Say it took 2.5 c.c. of alkaline solution, each cubic centimetre of which equals 9 mgms. of lactic acid (\bar{L});

$$\therefore 2.5 \text{ c.c.} \times 9 = 22.5 \text{ mgms. of lactic acid } (\bar{L}) \text{ in 10 c.c. of beer;}$$

$$\therefore 22.5 \times 7 = 157.5 \text{ parts per 70,000} \\ = \text{grains per gallon};$$

$$\therefore \frac{157.5}{8} = 19.6875 \text{ grains per pint of lactic acid } (\bar{L}).$$

(γ) Volatile.—Total acidity took 3.5 c.c. alkaline solution.

$$\begin{array}{rccccc} \text{Fixed} & , & , & \frac{2.5 \text{ c.c.}}{1.0 \text{ c.c.}} & , & , \end{array}$$

Therefore "volatile acidity" requires 1 c.c. of the alkaline solution (and each cubic centimetre of alkaline solution equals 6 mgms. of acetic acid, \bar{A});

$$\therefore 1 \times 6 = 6 \text{ mgms. of acetic acid } (\bar{A}) \text{ in 10 c.c. of beer} \\ = 6 \text{ parts per 70,000};$$

$$\therefore 10,000 : 70,000 :: 6 : x.$$

$$x = 42 \text{ parts per 70,000 (or grains per gallon)};$$

$$\therefore \frac{42}{8} = 5.25 \text{ grains per pint as acetic acid } (\bar{A}).$$

MILK.

(1.) *Amount of Fat present.*—Place 100 c.c. of distilled water in a glass-stoppered bottle, and drop in 2 c.c. or 3 c.c. of milk from a burette, and shake well to mix any cream present. Pour some into a Vogel's cup (glass), and look at the flame of a candle (placed at the other end of Vogel's instrument—a lactoscope). If you can see the flame (its outline), return the fluid you are examining to the bottle again, and add another cubic centimetre of milk. Again shake up the bottle, replace some in Vogel's cup, and again look at the flame of the candle through the fluid. If you cannot now see the flame distinctly, read off the number of cubic centimetres of milk dropped from the burette.

Now, by the following formula,* we estimate the amount of fat present:—

$$\frac{23.2}{\text{c.c.'s milk used}} + .23 = \text{percentage of fat.}$$

Say 3 c.c. were used,

$$\therefore \frac{23.2}{3} + .23 = 7.96 \text{ per cent. of fat present.}$$

(2.) *Amount of Lactin present.*—Draw 10 c.c. of milk into a test-tube, add 2 or 3 drops of acetic acid, and warm till the white milky appearance disappears. Put it into a 100 c.c. measure, wash out the test-tube with distilled water three times (emptying it each time into the same 100 c.c. measure), and finally make it up to 100 c.c. with distilled water.

Therefore we have 9 parts water and 1 part milk.

Thoroughly mix and then filter through 4 thicknesses of filter-paper, and we thus obtain a clear *whey*. Put this whey into a burette.

Next take 10 c.c. of standard Fehling solution in an

* Arrived at by comparison of results obtained from Vogel's instrument, and of chemical analysis.

evaporating dish, and add from 80 to 100 c.c. of distilled water. *Boil*, and, while boiling briskly, drop in the whey from the burette (1 c.c. at a time), continuing to boil till you add the next cubic centimetre. Continue till the whole of the Fehling is reduced. The deposit will be red.

Now read off the number of cubic centimetres of dilute whey used, and divide by 10 (10 c.c. of milk made up to 100 c.c. with distilled water); and 10 c.c. Fehling can be reduced by .0667 grammes of lactin.

Say 15 c.c. of whey were used,

$$\frac{15}{10} = 1.5 \text{ c.c. of milk must contain .0667 of lactin ;}$$

$$\therefore 1.5 : 100 :: .0667 : x.$$

$$x = 4.45 \text{ per cent. of lactin.}$$

BREAD.

Take 10 grammes of bread. (Bread requires 10 times its weight of water to digest it.)

Put in 100 c.c. of water, digest for half an hour, filter, and wash the filter 3 times.

Now drop in standard alkaline solution (liquor potassæ) to neutrality (using litmus-paper), and read the number of cubic centimetres used. It generally requires about 1.5 c.c., and each cubic centimetre of alkaline solution equals 6 mgms. of acetic acid.

Therefore in 10 grammes of bread there are—

$$1.5 \times 6 = 9 \text{ mgm. of acetic acid,}$$

$$\text{and } 7000 \text{ grains} = 1 \text{ lb.,}$$

$$10 \text{ lbs.} = 1 \text{ gallon ;}$$

$$\therefore 70,000 \text{ grains} = 1 \text{ gallon.}$$

We wish parts per 70,000, and we already have 9 parts in 10,000;

$$\therefore 10,000 : 70,000 :: 9 : x.$$

$$x = 6.3 \text{ grains of acetic acid in 1 lb. of bread.}$$

FLOUR.

Amount of Glutin present.—Take 10 grammes of flour, and make it into dough with 4.2 c.c. of distilled water, and allow it to stand for quarter of an hour in an evaporating dish. Then wash out the starch, pouring the supernatant starchy fluid into another vessel, and weigh (placing on capsule lid).

| | |
|------------------------------|---------------|
| Say lid weighs | 17.25 grammes |
| lid plus glutin weighs . . . | 20.25 grammes |

∴ glutin alone weighs . . . 3 grammes;
i.e., 3 grammes of glutin in 10 grammes of flour,
or 30 per cent. of *wet* glutin in 100 grammes of flour.

Usual ratio of *wet* to *dry* glutin is 2.9 : 1;

$$\therefore 2.9 : 30 :: 1 : x.$$

$$x = 10.34 \text{ per cent. of dry glutin.}$$

(The minimum amount of dry glutin is 8 per cent., and it ranges from 8 to 12 per cent.)

LIME JUICE.

Draw off 1 c.c. of the lime juice, and add about 20 cc. of water. Neutralise with standard alkaline solution, of which each cubic centimetre equals 6.4 mgm. of citric acid ($\text{C}_6\text{H}_8\text{O}_7$).

Say 12 c.c. alkaline solution have been used,

$$6.4 \times 12 = 76.8 \text{ mgms. citric acid in 1 c.c. lime juice}$$

$$= \text{parts per 1000},$$

and 70,000 grains = 1 gallon;

$$\therefore 1000 : 70,000 :: 76.8 : x.$$

$$x = 5376.0$$

$$= \text{parts per 70,000 or grains per gallon,}$$

and 20 ounces = 1 pint } i.e., 160 ounces in a gallon;
 8 pints = 1 gallon }

$$\therefore \frac{5376}{160} = \text{grains of citric acid per ounce}$$

$$= 33.6 \text{ grains } \textit{citric acid} (\bar{C}) \text{ per ounce of lime juice.}$$

(The minimum amount of citric acid present should be 30 grains per ounce.) . . .

VINEGAR.

Take 1 c.c. of vinegar (carefully), and add 20 c.c. of water.

Neutralise with standard alkaline solution, of which each cubic centimetre equals 6 mgms. of acetic acid (\bar{A}).

Say 8 c.c. alkaline solution have been used,

$$6 \times 8 = 48 \text{ mgm. acetic acid } (\bar{A}) \text{ in 1 c.c. of vinegar}$$

$$= \text{parts per 1000};$$

$$\therefore 1000 : 100 :: 48 : x.$$

$$x = 4.8 \text{ per cent. of acetic acid in the vinegar.}$$

(The minimum amount of acetic acid present should be 3 per cent.)

CARBON DIOXIDE IN AIR.

Estimation of Quantity.

Capacity of glass vessel used is $4\frac{1}{2}$ litres.

Fill it with water (in the room where the amount of CO_2 present in the air is to be determined). Now put in 60 c.c. of lime water, and close the mouth of the vessel with an indiarubber cap, and shake up the vessel and contents. Then allow it to stand for 6 hours. To determine the causticity of the lime, a solution of crystallised oxalic acid is used.

1st Causticity.—30 c.c. lime water = 40 c.c. oxalic acid,
 (28.5 c.c. = 1 ounce).

Take out 30 c.c. from the bottle, and determine its causticity now. Say it takes 40 c.c. oxalic acid solution.

2nd Causticity.—(Determined as before),

= 36 c.c. oxalic acid solution used.

(This is after the lime in the bottle has absorbed the CO₂ in the air.)

Difference between the two causticities equals the amount of lime precipitated by the CO_2 .

$$\begin{array}{l} \text{1st causticity} = 40 \text{ c.c.} \\ \text{2nd} \quad , \quad = 36 \text{ c.c.} \\ \hline \end{array}$$

or 4 mgms. of lime (CaO).

Only 30 c.c. were taken out, therefore 30 c.c. were left behind in the bottle, therefore multiply the amount by 2—

$4 \times 2 = 8$ mgm. lime, precipitated by the CO_2 in the bottle.

Molecular weight of $\text{CO}_2 = 44$,

„ „ CaO = 56,

$$\text{CaO} \quad \text{CaO} \quad \text{CO}_2;$$

$$\therefore 56 : 8 :: 44 : x.$$

$x = 6.3$ mgm. of CO_2 .

1 c.c. CO₂ weighs 1.9767 mgm.;

$$\therefore \frac{6.3}{1.9767} = 3.187$$

= number of cubic centimetres of CO_2 .

Capacity of jar was marked, say, 4325 c.c.; and, as we put in 60 c.c. of lime water first, deduct this 60 c.c. (space occupied by the lime water)—

$$4325 - 60 = 4265 \text{ c.c.} \\ = \text{nett capacity.}$$

We require volumes per 1000,

$$\therefore 4265 : 1000 :: 3.187 :: x. \\ x = .7472 \\ = \text{amount of volumes of CO}_2 \text{ per 1000.}$$

Now correct for temperature:—

Air expands .2 per cent. for every degree Fahrenheit above the standard 32° Fh. (freezing-point of water).

Suppose the temperature to have been 50° Fh.,

$$50^{\circ} - 32^{\circ} = 18^{\circ}, \\ \text{and } 18^{\circ} \times .2 = 3.6; \\ \text{i.e., 100 vols. at } 32^{\circ} \text{ Fh.} = 103.6 \text{ vols. at } 50^{\circ} \text{ Fh.;} \\ \therefore 100 : 103.6 :: .7472 : x. \\ x = .7472 \times 1.036 \\ = .774 \text{ volumes of CO}_2 \text{ per 1000 volumes of air.}$$

AVERAGE COMPOSITION OF MILK.

| | Per Cent. | | | | |
|--------|-----------|---|---|---|--------------|
| Water | . | . | . | . | 88 |
| Fat | . | . | . | . | 3 |
| Casein | . | | . | . | 4 |
| Sugar | . | . | . | . | 4.3 |
| Ash | . | . | . | . | 0.7 |
| | | | | | <u>100.0</u> |

Physical Characters.—Milk should be opaque, white in colour, without any peculiar taste or smell, and without any deposit. In its *reaction*, it should be either neutral or faintly acid or alkaline.

Specific Gravity.—Lies between 1026 and 1035. (The sp. gr. of the whey should be taken; it is generally about 1028.) The presence of much cream lowers the specific

Classification of Waters (Parkes).

| PHYSICAL CHARACTERS. <i>Chemical Constituents (in Parts per Million.)</i> | (1.) PURE. | | (4.) IMPURE. | |
|--|--|--|---|--|
| | Colourless, or bluish tint; transparent, sparkling, and well aerated; no sediment visible to naked eye; no smell; taste palatable. | (2.) USABLE. As in (1), but may be of a greenish tint. If any sediment, easily separated by filtration. | (3.) SUSPICIOUS. Yellow or strong green colour; turbid; suspended matter considerable; no smell, but any marked taste. | (4.) IMPURE. Yellow or brown colour; turbid, not easily purified by coarse filtration; large amount of suspended matter; marked smell or taste. |
| 1. Total dissolved solids | Under 75. | Under 450. | 450 to 750. | Above 750. |
| 2. Loss in dissolved solids on ignition | Under 15; no blackening on ignition. | Under 45; may blacken, but no nitrous fumes. | 45 to 75; blackening and nitrous fumes. | Above 75; much blackening and nitrous fumes. |
| 3. Chlorine | Under 15. | Under 45. | 45 to 75. | Above 75. |
| 4. Nitrates | None. | None. | Present. | Marked. |
| 5. Nitrates | None or trace-only. | Under 4° Clark. | Above 4° Clark. | Large. |
| 6. Hardness (permanent) | 2° Clark. | Under 4° Clark. | Above 6° Clark. | |
| 7. Ammonia (free) | Under 0.02. | Under 0.05. | 0.05 to 0.1. | Above 0.1. |
| 8. Ammonia (albuminoid) | Under 0.05. | Under 0.1. | 0.1 to 0.125. | Above 0.125. |
| 9. Organic carbon | Under 1. | Under 2. | Above 2. | Above 3. |
| 10. Organic nitrogen | Under 0.2. | Under 0.3. | Above 0.3. | Above 0.3. |
| 11. Oxygen taken from acid permanganate | Under 1. | Under 1.5. | Above 1.5. | Above 2. |
| 12. Sulphides | None. | None. | None. | Present. |
| 13. Metals | None. | Trace of iron. | Trace of iron. | Iron or lead. |
| MICROSCOPIC CHARACTERS. | | As in (1). | | Bacteria of any kind; fungi; vegetable and animal forms of low type; epithelia or other animal structures; evidences of sewage; ova of parasites. |
| | | | | Vegetable and animal forms, more or less pale and colourless; organic débris; fibres of clothing, or other evidence of house refuse. |

Table of Percentages of Absolute Alcohol, at 60° Fahrenheit (TRALLES).

| Vols. per Cent. | Weight per Cent. | Specific Gravity at 60° Fh. | Weight per Cent. | Vols. per Cent. | Specific Gravity at 60° Fh. | Weight per Cent. |
|-----------------------|------------------------|-----------------------------------|------------------------|-----------------------|-----------------------------------|------------------------|-----------------------|-----------------------------------|------------------------|-----------------------|-----------------------------------|------------------------|-----------------------|-----------------------------------|------------------------|
| 0 | 0 | 1.0000 | .9976 | 26 | 21.30 | .9689 | 51 | 43.47 | .9315 | 76 | 69.05 | .8739 | 77 | 70.18 | .8712 |
| 1 | 0.80 | .9976 | .9961 | 27 | 22.14 | .9679 | 52 | 44.42 | .9295 | 77 | 71.31 | .8685 | 78 | 72.45 | .8658 |
| 2 | 1.60 | .9961 | .9947 | 28 | 22.99 | .9668 | 53 | 45.36 | .9275 | 78 | 73.59 | .8631 | 80 | 74.74 | .8603 |
| 3 | 2.40 | .9947 | .9933 | 29 | 23.84 | .9657 | 54 | 46.32 | .9254 | 81 | 75.91 | .8575 | 82 | 77.09 | .8547 |
| 4 | 3.20 | .9933 | .9919 | 30 | 24.69 | .9646 | 55 | 47.29 | .9234 | 83 | 78.29 | .8518 | 84 | 79.50 | .8488 |
| 5 | 4.00 | .9919 | .9906 | 31 | 25.55 | .9634 | 56 | 48.26 | .9213 | 85 | 80.71 | .8458 | 86 | 80.11 | 84.28 |
| 6 | 4.81 | .9906 | .9893 | 32 | 26.41 | .9622 | 57 | 49.23 | .9192 | 87 | 81.94 | 88 | 88 | 83.19 | .8397 |
| 7 | 5.62 | .9893 | .9881 | 33 | 27.27 | .9609 | 58 | 50.21 | .9170 | 88 | 89.75 | .8332 | 89 | 90.00 | 82.99 |
| 8 | 6.43 | .9881 | .9869 | 34 | 28.13 | .9596 | 59 | 51.20 | .9148 | 90 | 91.07 | .8194 | 91 | 92.46 | .8265 |
| 9 | 7.24 | .9869 | .9857 | 35 | 28.99 | .9583 | 60 | 52.20 | .9126 | 93 | 93.89 | .8118 | 93 | 94.46 | .8365 |
| 10 | 8.05 | .9857 | .9845 | 36 | 29.86 | .9570 | 61 | 53.20 | .9104 | 94 | 95.34 | .8077 | 94 | 96.00 | 83.30 |
| 11 | 8.87 | .9845 | .9834 | 37 | 30.74 | .9556 | 62 | 54.21 | .9082 | 95 | 96.84 | .8034 | 95 | 97.00 | 82.99 |
| 12 | 9.69 | .9834 | .9823 | 38 | 31.62 | .9541 | 63 | 55.21 | .9059 | 96 | 98.39 | .7988 | 96 | 99.00 | 82.00 |
| 13 | 10.51 | .9823 | .9812 | 39 | 32.50 | .9526 | 64 | 56.22 | .9036 | 97 | 99.84 | .7939 | 97 | 100.00 | 81.00 |
| 14 | 11.33 | .9812 | .9802 | 40 | 33.39 | .9510 | 65 | 57.24 | .9013 | 98 | 100.00 | 80.00 | 98 | 100.00 | 79.99 |
| 15 | 12.15 | .9802 | .9791 | 41 | 34.28 | .9494 | 66 | 58.27 | .8989 | 99 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 16 | 12.98 | .9791 | .9781 | 42 | 35.18 | .9478 | 67 | 59.32 | .8965 | 100 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 17 | 13.80 | .9781 | .9771 | 43 | 36.08 | .9461 | 68 | 60.38 | .8941 | 100 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 18 | 14.63 | .9771 | .9761 | 44 | 36.99 | .9444 | 69 | 61.42 | .8917 | 100 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 19 | 15.46 | .9761 | .9751 | 45 | 37.90 | .9427 | 70 | 62.50 | .8892 | 100 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 20 | 16.28 | .9751 | .9741 | 46 | 38.82 | .9409 | 71 | 63.58 | .8867 | 100 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 21 | 17.11 | .9741 | .9731 | 47 | 39.75 | .9391 | 72 | 64.66 | .8842 | 100 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 22 | 17.95 | .9731 | .9720 | 48 | 40.66 | .9373 | 73 | 65.74 | .8817 | 100 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 23 | 18.78 | .9720 | .9710 | 49 | 41.59 | .9354 | 74 | 66.83 | .8791 | 100 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 24 | 19.62 | .9710 | .9700 | 50 | 42.52 | .9335 | 75 | 67.93 | .8765 | 100 | 100.00 | 79.99 | 100 | 100.00 | 79.99 |
| 25 | 20.46 | | | | | | | | | ... | ... | ... | ... | ... | ... |

gravity of milk, and on removing the cream it will rise about 2° or 3° ; that is, at 60° Fh. It varies in the tropics, thus :—

| | | | |
|------------------------|---------------|-----|----------|
| * Temperature of milk, | 39° | Fh. | = 1031 |
| " | 60° | " | = 1030 |
| " | 70° | " | = 1029 |
| " | 80° | " | = 1027.5 |
| " | 90° | " | = 1025.8 |
| " | 100° | " | = 1024.0 |

The specific gravity will also indicate any addition of water to the milk, there being a loss of 3° for every 10 per cent. of water added at 60° Fh.

Total Solids, got by evaporation, should be about 12 per cent. (of which 3 to 4 per cent. is fat).

ADULTERATIONS OF MILK.

(1.) *Water*, detected by lowered specific gravity, and in a diminution of total solids or ash.

(2.) *Starch*, detected by addition of iodine. *Dextrin*, detected by addition of iodine, after boiling with a drop of acetic acid.

(3.) *Turmeric*, turned orange red by addition of liquor potassæ.

(4.) *Glycerine*, sweetens milk unnaturally, and prevents drying of solids on evaporation.

(5.) *Chalk* subsides as a deposit. *Sodium carbonate* causes the ash to effervesce unless enough has been added to produce an alkaline reaction of milk.

(6.) *Salt*, detected in the ash.

(7.) *Magnesium Carbonate*, *Tragacanth*, and *Arrowroot* (to represent cream), detected by the microscope.

* Parkes' "Practical Hygiene."

STANDARD SOLUTIONS (Parkes).

For Chlorine.

(1.) *Silver Nitrate Solution*.—4.788 grammes of silver nitrate in 1 litre of distilled water.

1 c.c. of solution = 1.00 mgm. of chlorine.

„ „ = 1.65 „ sodium chloride.

„ „ = 2.10 „ potassium chloride.

„ „ = 1.51 „ ammonium chloride.

This solution can be "standardised" with a solution of pure sodium chloride, 1.648 to the litre, 1 c.c. of which equals 1 mgm. of chlorine.

(2.) *Potassium Monochromate Solution*.—50 grammes of potassium monochromate are dissolved in 1 litre of distilled water. Solution of silver nitrate is added until a permanent red precipitate is formed, which is allowed to settle.

For Hardness.

(1.) *Soap Solution*.—Dissolve some soft soap (pharmacopœial) in dilute spirit, and graduate by means of the following baryta solution :—

Barium nitrate 0.26 gramme.

Distilled water 1 litre.

2.2 c.c. (22 "measures") of standard soap solution produce a permanent lather with 50 c.c. of the above solution.

1 measure ($\frac{1}{10}$ c.c.) of soap solution = 0.00025 gm. = 0.25 mgm. of calcium carbonate.

Correction for lather = - 2 measures of soap.

Short factors (when 50 c.c. water taken)—

For degrees of Clark's scale (1 : 70,000) = 0.35.

„ „ metrical „ (1 : 100,000) = 0.50.

(2.) A weaker solution, each measure ($\frac{1}{10}$ c.c.) of which

is equal to 0.07 mgm. of CaCO_3 is at times used. The correction for lather would be 7 measures of soap. The corrected number of measures, divided by 10, gives the hardness in Clark's scale, or multiplied by 0.14 the degrees of hardness on the metrical scale.

For Oxidisable Matter in Water.

(1.) *Permanganate Solution*.—0.395 of potassium permanganate in 1 litre of water.

100 c.c. are decolorised by 100 c.c. of oxalic acid solution, exactly. [Vide Oxalic Acid, sol. (3).]

1 c.c. of permanganate solution used with acid yields 0.10 mgm. of oxygen.

1 c.c. of permanganate solution used with alkali yields 0.06 mgm. of oxygen.

1 c.c. of permanganate solution exactly oxidises 0.2875 mgm. nitrous acid (NO_2).

1 c.c. of permanganate solution exactly oxidises 0.2125 mgm. hydrogen sulphide (H_2S).

1 c.c. of permanganate solution exactly oxidises 0.7000 mgm. of iron (Fe).

1 c.c. of permanganate solution exactly oxidises 0.9000 mgm. of ferrous oxide (FeO).

(2.) *Potassium Iodide Solution*.—A 10 per cent. solution of the pure potassium iodide, recrystallised from alcohol.

(3.) *Dilute Sulphuric Acid Solution*.—1 volume of pure sulphuric acid is mixed with 3 volumes of distilled water, and permanganate solution dropped in until the whole retains a very faint pink colour after warming to 80° Fh. for 4 hours.

(4.) *Sodium Hyposulphite Solution*.—1 gramme of crystallised sodium hyposulphite dissolved in 1 litre of water.

(5.) *Starch Solution*.—1 gramme of starch intimately mixed with $\frac{1}{2}$ litre of distilled water, then boiled briskly for 5 minutes, filtered and allowed to settle.

For Free and Albuminoid Ammonia.

(1.) *Ammonium Chloride Solution for Nesslerising.*—0.315 gramme of ammonium chloride in 1 litre of water (*Strong solution*). Take 100 c.c. of this solution and dilute to 1 litre (*Standard solution*), 1 c.c. = 0.01 mgm. of ammonia (NH_3), or 0.0082 mgm. of nitrogen.

(2.) *Nessler's Solution.*—Dissolve 35 grammes of potassium iodide in 100 c.c. of distilled water. Dissolve 17 grammes of mercuric chloride in 300 c.c. of distilled water; warm if necessary and allow to cool. Add the mercuric solution to the iodide solution until a perceptible permanent precipitate is produced. Then dilute with a 20 per cent. solution of sodium hydrate (caustic soda) up to 1000 c.c. (1 litre); add mercuric chloride solution until a permanent precipitate again forms, allow the precipitate to settle, and then decant off the clear solution.

(3.) *Alkaline Potassium Permanganate Solution (for Albuminoid Ammonia).*—Dissolve 200 grammes of potassium hydrate and 8 grammes of pure potassium permanganate in 1100 c.c. of distilled water, and boil the solution rapidly till concentrated to 1000 c.c.

(4.) *Distilled Water free from Ammonia.*—The S.P.A. recommend boiling ordinary distilled water with 1 per 1000 of pure ignited sodium carbonate. If the water is distilled with a little phosphoric acid (as recommended by Notter), it comes over quite free. Test with a little Nessler's solution.

For Nitric Acid in Nitrates.

(1.) *Metallic Aluminium.*—As thin foil.

(2.) *Solution of Sodium Hydrate.*—Dissolve 100 grammes of solid sodium hydrate in 1 litre of distilled water. When cold, introduce a strip of about 100 square centimetres (say

15 square inches) of aluminium foil previously heated to just short of redness, wrapped round a glass rod; when the aluminium is dissolved, boil the solution briskly in a porcelain basin until about $\frac{1}{3}$ of its volume has evaporated; allow it to cool, and make it up to its original volume with water free from ammonia. The solution must be tested by a blank experiment to prove the absence of nitrates.

(3.) *Standard Solution of Ammonium Chloride* (*vide above*).

(4.) *Nessler's Solution* (*vide above*).

For Nitrous Acid in Nitrites.

(1.) *Solution of Meta-phenylenediamine*. — Dissolve 5 grammes of meta-phenylenediamine in 1 litre of distilled water, rendered acid with sulphuric acid. Decolorise, if necessary, with animal charcoal.

(2.) *Solution of Dilute Sulphuric Acid*. — 1 volume of pure sulphuric acid to 2 volumes of distilled water.

(3.) *Solution of Potassium Nitrite*. — Dissolve 0.335 gramme of pure silver nitrite in hot water, and decompose it with a slight excess of potassium chloride. After cooling, make the solution up to 1 litre, allow the chloride of silver to settle, and dilute each 100 c.c. of the clear supernatant liquid again to 1 litre. 1 c.c. of this diluted solution = 0.01 mgm. of NO_2 . The nitrites may also be determined by the permanganate solution.

For Phosphoric Acid.

One part of pure molybdic acid is dissolved in 4 parts of ammonia, sp. gr. 0.960. This solution, after filtration, is poured with constant stirring into 15 parts of nitric acid of sp. gr. 1.20. It should be kept in the dark, and carefully decanted from any precipitate which may form.

Alkaline Solution for Acidities.

Take liquor sodæ (or potassæ) of pharmacopœial strength, and dilute with 8 or 9 parts of distilled water. Graduate with *oxalic acid solution (1)*.

1 c.c. standard alkaline solution = 6.3 mgm. oxalic acid.

“ “ “ “ = 6.0 “ glacial acetic acid.

“ “ “ “ = 9.0 “ lactic acid.

“ “ “ “ = 7.5 “ tartaric acid.

“ “ “ “ = 6.4 “ citric acid.

Oxalic Acid Solutions.

Solution (1).—Take 6.3 grammes of crystallised oxalic acid, and dissolve in 1 litre of water.

10 c.c. exactly neutralise 10 c.c. of standard alkaline solution.

Solution (2).—Take 100 c.c. of solution (1), and add 180 c.c. of distilled water; or dissolve 2.25 grammes of crystallised oxalic acid in 1 litre of distilled water.

This makes the solution for testing the alkalinity of lime or baryta water.

1 c.c. neutralises 1 mgm. of lime (CaO).

“ “ 2.73 mgm. of baryta (BaO).

Solution (3).—Take 100 c.c. of solution (1), and add 700 c.c. of distilled water; or dissolve 0.7875 gramme of crystallised oxalic acid in 1 litre of distilled water.

This is the solution for graduating the permanganate. 100 c.c. exactly decolorise 100 c.c. of permanganate in presence of sulphuric acid.

Iodine Solution for Hydrogen Sulphide.

Dissolve 6.35 grammes of iodine in 1 litre of distilled water by the aid of a little potassium iodide.

1 c.c. = 0.85 mgm. of H_2S .

If a litre of water be taken for examination, the short factor for cubic inches per gallon is 0.164. Starch is used as the indicator.

Standard Lead Solution.

Dissolve 0.1831 grammes crystallised acetate of lead [$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{H}_2\text{O}$] in 1 litre of distilled water.

Each cubic centimetre contains 0.1 mgm. of metallic lead (Pb).

Dilute Acid Solutions

Are generally 1 part of acid to 9 of distilled water, unless otherwise specified.

Qualitative Solutions

Are *saturated* unless otherwise specified.

Brucine Solution (for Nitric Acid).

1 gramme of brucine to 1 litre of distilled water.

Solution of Potassium Iodide and Starch (for Nitrous Acid).

Potassium iodide 1 gramme, starch 20 grammes, water 500 c.c. Make the starch, filter when cold, and then add the potassium iodide.

This mixture does not keep well, and must be made fresh from time to time, or the potassium iodide and starch solutions, already mentioned, may be used instead.

Solution of Gold Chloride (for Oxidisable Matter in Water).

1 gramme of gold chloride dissolved in 1 litre of water.

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Laboratory analysis of water, milk, bread



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